Claims 3-21-06

1. (Previously Amended) Method of forming a hologram from a information containing mask, comprising the following steps:
- arranging a substrate bearing a layer of a holographic recording medium on a first face of a coupling element and in optical contact therewith;
- arranging a information containing mask in a spaced relationship and parallel to the substrate;
- generating an illumination light beam and then splitting the light beam into an object beam and a reference beam;
- - directing the reference beam to a second face of the coupling element in a way that the condition for total internal reflection at the interface between the recording medium and the ambient medium is fulfilled
- directing the object beam through the mask to the substrate such that it overlaps with the reference beam in the holographic recording medium;
- employing a photoresist as the holographic recording medium; and
- arranging the planes of polarisation of the object and reference beams incident on the holographic recording medium such that their polarisation vectors are substantially mutually orthogonal in the holographic recording medium and such that the polarisation vectors of the incident and totally internally reflected reference beams are also substantially orthogonal; and
- the step of employing a photoresist includes employing a photoresist whose layer thickness is less than 500nm.

2. (Currently Amended) Method according to claim 1, characterized in that substantially only the a transmission hologram is recorded in the holographic recording layer.

3. (Previously Amended) Method according to claim 1, characterized in that a photoresist is employed whose refractive index at the exposure wavelength is greater than 1.6.

4. (Previously Presented) Method according to claim 1, characterized in that the plane of polarisation of the object beam is at 45° to the plane of incidence of the reference beam at the holographic recording layer.

5. (Previously Presented) Method according to claim 1, characterized in that the photoresist material is selected such that its thickness (d) and absorption (a) meet the condition $a * d < 1$.

6. (Previously Presented) Method according to claim 1, characterized in that the photoresist is selected such that its contrast described by its gamma-value satisfies the condition $\gamma < 3$.

7. (Canceled) Method according to claim 1, characterized in the photoresist is selected such that its resolution described by the smallest period of grating that can be optically recorded in the material is with a modulation depth $(d_{max} - d_{min})/ (d_{max} - d_{min}) > 25\%$ satisfies the condition $\Lambda < 200$ nm.

8. (Previously Amended) Method according to claim 1, characterized in that laser light of a wavelength below 300nm for recording the hologram is used.

9. (Canceled) Method according to claim 1, characterized in the polarisation angles are selected according to the refractive index of the photoresist.

10. (Canceled) Method according to claim 1, characterized in that a combination of polarisation angles of between 37 to 44° for the reference beam and -43 to -47° for the object beam with respect to the plane of incidence are applied.

11. (Previously Presented) Method according to claim 1, characterized in that the intensity of the reference beam exceeds that of the object beam.

12. (Canceled) Method according to claim 1, characterized in that the intensity of the reference beam exceeds that of the object beam by at least a factor 2.

13. (Previously Amended) Method according to claim 1, characterized in that the intensity ratio of the reference and object beams is between 3:1 and 5:1.

14. (Previously Amended) Method according to claim 1, characterized in that the thickness of the photoresist layer is between 100 and 300 nm.

15. (Canceled) Method according to claim 1, characterized in that the image recorded in the photoresist as surface relief hologram is transferred into the substrate material by an etching process.

16. (Canceled) Method according to claim 1, characterized in that the etching process is a plasma etching process.

17. (Previously Amended) Method according to claim 1, characterized in that the illumination beam is scanned in a first direction such that the reference and object beams scan across the holographic recording medium and the mask respectively, stepping the illumination beam in a second direction perpendicular to the first direction, and then scanning the illumination beam again in the first direction and so

on, such that the reference beam and object beam travel simultaneously across the face of the substrate in optical contact with the first face of the coupling element.

18. (Currently Amended) Method according to claim 1 characterized in that the gap between the holographic recording layer and the mask is determined, ~~e.g. interferometrically,~~ and then the distance between the hologram and the recording medium adjusted to a predetermined value.

19. (Canceled) Method according to claim 1 characterized in that in the hologram reconstruction process the distance between the hologram and the substrate onto which the holographically recorded image is to be reconstructed is adjusted to the value as maintained between the holographic recording layer and the mask in the hologram formation process.

20. (Previously Amended) Method according to claim 1 characterized in that the reference beam is directed to a second face of the coupling element in a way that the condition for total internal reflection at the interface between the recording medium and the ambient medium is fulfilled and so that the angle of incidence of the beam in the recording layer is less than 45°.

21. (Canceled) Use of the method according to claim 1 for recording features of less than 1 μm contained in a mask in a hologram for use in microlithography.

22. (Canceled) Method of forming a hologram from a information containing mask, comprising the following steps:
- arranging a substrate bearing a layer of a holographic recording medium on a first face of a coupling element and in optical contact therewith;
- arranging a information containing mask in a spaced relationship and parallel to

the substrate;

- generating an illumination light beam and then splitting the light beam into an object beam and a reference beam;
- directing the object beam through the mask to the substrate such that it overlaps with the reference beam in the holographic recording medium;
- employing a photoresist as the holographic recording medium;
- directing the reference beam to a second face of the coupling element in a way that the condition for total internal reflection at the interface between the recording medium and the ambient medium is fulfilled and so that the angle of incidence of the beam in the recording layer is less than 45°;
- arranging the planes of polarisation of the object and reference beams incident on the holographic recording medium such that their polarisation vectors are substantially mutually orthogonal in the holographic recording medium and such that the polarisation vectors of the incident and totally internally reflected reference beams are also substantially orthogonal; and
- the step of employing a photoresist includes employing a photoresist whose layer thickness is less than 500nm.

23. (Canceled) Method according to claim 22 characterized in that a photoresist is employed whose refractive index at the exposure wavelength is greater than 1.6.

24. (Canceled) Method according to claim 22, characterized in that substantially only the transmission hologram is recorded in the holographic recording layer.

25. (Currently Amended) Total internal reflection holographic recording apparatus for recording a hologram from a mask, comprising
- an optical coupling element for receiving a substrate on a first face;
- a substrate bearing a holographic recording medium, the substrate being in

optical contact with said first face of the optical coupling element,

- at least one light source for generating a light beam;
- optical means for generating a collimated light beam of a selected cross-section;
- means, ~~e.g. a beam-splitter, prism or the like,~~ for generating two coherent light beams, a reference light beam and an object light beam;
- means for directing the reference light beam at a second face of the coupling element such that it illuminates the interface between the holographic recording medium and the ambient medium at an angle greater than the critical angle;
- means for directing the object light beam at the first face of the coupling element such that it is aligned with the reference beam in the plane of the holographic recording medium on the substrate in contact with the first face;
- the holographic recording medium is a photoresist; and
- means are provided for arranging the planes of polarisation of the object and reference beams incident on the holographic recording medium such that their polarisation vectors are substantially mutually orthogonal in the holographic recording medium and such that the polarisation vectors of the incident and totally internally reflected reference beams are substantially orthogonal; and
- said photoresist being a layer having a thickness less than 500nm.

26. (Previously Amended) Apparatus according to claim 25 characterized in that the at least one light source is a laser light source emitting light of a wavelength below 300nm.

27. (Canceled) Apparatus according to claim 25, characterized in that the photoresist material is such that its thickness (d) and absorption (a) meet the condition $a * d < 1$.

28. (Canceled) Apparatus according to claim 25, characterized in that the photoresist material is such that that its contrast described by its gamma factor satisfies the

condition $\gamma < 3$.

29. (Previously Amended) Apparatus according to claim 25, characterized in that a combination of polarisation angles of between 37 to 44°for the reference beam and -43 to -47° for the object beam are applied.

30. (Previously Presented) Apparatus according to claim 25, characterized in that means are provided for adjusting the intensities of the object and reference beams such that the intensity of the object beam exceeds that of the reference beam.

31. (Canceled) Apparatus according to claim 25, characterized in that the intensity of the object beam exceeds that of the reference beam by at least of a factor 2.

32. (Previously Amended) Apparatus according to claim 25, characterized in that the thickness of the photoresist layer is between 100 and 300 nm.

33. (Canceled) Apparatus according to claim 25, characterized in that means are provided for scanning and stepping the incident light beam in a raster scan across the beam splitting means in a first and in a second direction, respectively, such that the reference and object beams travel simultaneously across the first face or the substrate in optical contact with the first face;

34. (Canceled) Apparatus according to claim 25 further comprising
- means for measuring the gap between the hologram and a wafer being arranged in a spaced relationship to the hologram; and
- means for adjusting the parallelism and/or separation between the hologram and the wafer.

35. (Previously Presented) Apparatus according to claim 25, further characterized in that the directing means for the reference light beam further arranges that the angle of incidence of the reference beam in the holographic recording layer is less than 45°.

36. (Canceled) Apparatus according to claim 25 characterized in that the photoresist employed has a refractive index at the exposure wavelength of greater than 1.6.

37. (Currently Amended) Total internal reflection holographic recording apparatus or system for recording a hologram from a mask, comprising

- an optical coupling element for receiving a substrate on a first face;
- a substrate bearing a holographic recording medium, the substrate being in optical contact with said first face of the optical coupling element,
- at least one light source for generating a light beam;
- optical means for generating a collimated light beam of a selected cross-section;
- means, ~~e.g. a beam-splitter, prism or the like,~~ for generating two coherent light beams, a reference light beam and an object light beam;
- means for directing the reference light beam at a second face of the coupling element such that it illuminates the interface between the holographic recording medium and the ambient medium at an angle greater than the critical angle;
- means for directing the object light beam at the first face of the coupling element such that it is aligned with the reference beam in the plane of the holographic recording medium on the substrate in contact with the first face;
- the holographic recording medium is a photoresist;
- means are provided for arranging the planes of polarisation of the object and reference beams incident on the holographic recording medium such that their polarisation vectors are substantially mutually orthogonal in the holographic recording medium and such that the polarisation vectors of the incident and totally

internally reflected reference beams are substantially orthogonal; and

- in that the directing means for the reference light beam further arranges that the angle of incidence of the reference beam in the holographic recording layer is less than 45°; and
- said photoresist being a layer having a thickness less than 500nm.

38. (Canceled) Apparatus according to claim 37, characterized in that the at least one light source is a laser light source emitting light of a wavelength below 300nm.

39. (Canceled) Hologram recorded in a recording medium according to claim 1, characterized in that a photoresist is employed whose refractive index at the exposure wavelength is greater than 1.6.

40. (New) Method according to claim 1, characterized in the photoresist is selected such that its resolution described by the smallest period of grating that can be optically recorded in the material is with a modulation depth $(d_{max} - d_{min})/(d_{max} + d_{min}) \geq 25\%$ satisfies the condition $\Lambda \leq 200$ nm.

41. (New) Method according to claim 1, characterized in the polarisation angles are selected according to the refractive index of the photoresist.

42. (New) Method according to claim 1, characterized in that a combination of polarisation angles of between 37 to 44° for the reference beam and -43 to -47° for the object beam with respect to the plane of incidence are applied.

43. (New) Method according to claim 1, characterized in that the intensity of the reference beam exceeds that of the object beam by at least a factor 2.

44. (New) Method according to claim 1, characterized in that the image recorded in the photoresist as surface relief hologram is transferred into the substrate material by an etching process.

45. (New) Method according to claim 1, characterized in that the etching process is a plasma etching process.

46. (New) Method according to claim 1 characterized in that in the hologram reconstruction process the distance between the hologram and the substrate onto which the holographically recorded image is to be reconstructed is adjusted to the value as maintained between the holographic recording layer and the mask in the hologram formation process.

47. (New) Use of the method according to claim 1 for recording features of less than 1 μm contained in a mask in a hologram for use in microlithography.

48. (New) Method of forming a hologram from a information containing mask, comprising the following steps:
- arranging a substrate bearing a layer of a holographic recording medium on a first face of a coupling element and in optical contact therewith;
- arranging a information containing mask in a spaced relationship and parallel to the substrate;
- generating an illumination light beam and then splitting the light beam into an object beam and a reference beam;
- directing the object beam through the mask to the substrate such that it overlaps with the reference beam in the holographic recording medium;

- employing a photoresist as the holographic recording medium;
- directing the reference beam to a second face of the coupling element in a way that the condition for total internal reflection at the interface between the recording medium and the ambient medium is fulfilled and so that the angle of incidence of the beam in the recording layer is less than 45°;
- arranging the planes of polarisation of the object and reference beams incident on the holographic recording medium such that their polarisation vectors are substantially mutually orthogonal in the holographic recording medium and such that the polarisation vectors of the incident and totally internally reflected reference beams are also substantially orthogonal; and
- the step of employing a photoresist includes employing a photoresist whose layer thickness is less than 500nm.

49. (New) Method according to claim 48 characterized in that a photoresist is employed whose refractive index at the exposure wavelength is greater than 1.6.

50. (New) Method according to claim 48, characterized in that substantially only a transmission hologram is recorded in the holographic recording layer.

51. (New) Apparatus according to claim 50, characterized in that the photoresist material is such that its thickness (d) and absorption (a) meet the condition $a * d \leq 1$.

52. (New) Apparatus according to claim 50, characterized in that the photoresist material is such that that its contrast described by its gamma factor satisfies the condition $\gamma \leq 3$.

53. (New) Apparatus according to claim 50, characterized in that the intensity of the object beam exceeds that of the reference beam by at least of a factor 2.

54. (New) Apparatus according to claim 50, characterized in that means are provided for scanning and stepping the incident light beam in a raster scan across the beam splitting means in a first and in a second direction, respectively, such that the reference and object beams travel simultaneously across the first face or the substrate in optical contact with the first face;

55. (New) Apparatus according to claim 50 further comprising
- means for measuring the gap between the hologram and a wafer being arranged in a spaced relationship to the hologram; and
- means for adjusting the parallelism and/or separation between the hologram and the wafer.

56. (New) Apparatus according to claim 50 characterized in that the photoresist employed has a refractive index at the exposure wavelength of greater than 1.6.

57. (New) Apparatus according to claim 56, characterized in that the at least one light source is a laser light source emitting light of a wavelength below 300nm.

58. (New) Hologram recorded in a recording medium according to claim 1, characterized in that a photoresist is employed whose refractive index at the exposure wavelength is greater than 1.6.

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